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INTEGRATING LOW COST/OPEN SOURCE GIS AND REMOTE SENSING IN URBAN PLANNING IN DEVELOPING COUNTRIES – CASE OF BLANTYRE CITY, MALAWI

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Abstract

The manual method to manage urban planning and development control has always been the traditional way. In the late 1990s, thanks to the advent of Geographic Information System (GIS) and remote sensing technologies, the process of urban planning in Malawi received a new impetus. Capturing the spatial details by remote sensing either by satellite images and organizing the data under GIS offered tremendous ease in undertaking urban planning activities. Unfortunately among other problems, the practical use of GIS has always been hampered by the lack of adequate resources to procure GIS software and satellite images. Use of low cost/open source GIS software and online free satellite images can be a solution to spatial and non-spatial data management for urban planning management and development control. This can help many municipal councils in developing countries reduce urban planning challenges. In this paper, various examples have been used to show how low cost/open source GIS software and free satellite image integration in urban planning management and development control can solve planning problems.

Key Words:

GIS, integration, Remote Sensing, satellite images, urban planning

1.0 INTRODUCTION

The Town and Regional Planning Act govern land-use, physical planning and urban management activities in Malawi. Preparation of existing land use maps, population, economic activity projections, zoning patterns, transport infrastructure, public facilities' reservation and development control regulations are the essential elements of this planning process. Structure Plan is the end product that governs the future development of an urban area. The manual survey to prepare an existing land-use map has been the traditional way. This very first step in formulating the plan takes considerable time and efforts particularly for cities and large towns. In the late 1990s, thanks to the advent of Geographic Information System (GIS) and remote sensing technologies, the process of urban planning in Malawi received a new impetus. Capturing the spatial details by remote sensing either by satellite imageries or aerial photographs and organizing the data under GIS offered tremendous ease in undertaking urban planning activities. Unfortunately, the practical use of GIS in many developing countries is hampered by lack of resources to procure GIS software and satellite images among others. Use of low cost or open source GIS software and online free satellite images can be a solution to spatial and non-spatial data management for urban planning and management. Low cost/open source GIS software and free satellite images are used to solve day to day urban planning management and development control problems in developing countries.

2.0 ADOPTING LOW COST GIS AND REMOTE SENSING

GIS is defined as a computer aided decision support and planning tool which integrates spatial data from maps and other auxiliary data (attribute data) for a geographical area of interest. It combines hardware, software and people to achieve its performance (Arnoff, 1995). Remote Sensing on the other hand involve use of high-resolution satellite imageries or aerial photographs to support urban planning and management activities. The Blantyre City Ginnery Corner satellite[1] imagery as shown in *Figure 1a* below and *1b in Appendix 1* is currently used in development control.

Figure 1a.Ginnery Corner, Blantyre satellite[1] imagery

Figure 1b.Ginnery Corner, Blantyre satellite[1] imagery

In many urban areas of the developing countries, GIS is a relatively new phenomenon. According to Henk and Stillwell (1990), the growth of GIS in the developing world was driven by push factors such as population growth and urbanisation whilst technology edge was the main factor in the developed world. Decision makers saw GIS as an opportunity to improve the economic development process of industrialization and compete in the global marketplace. Never-the-less few local authorities in the developing world have invested in GIS due to high costs and lack of implementation support (Sengupta 2001).

[1] *Quick Bird Image of Ginnery Corner, Blantyre City – quickbird@maps-geosystems.com*

In many African countries the implementation has also been restricted by factors such as financial, political, technical, technological, educational, organizational and human behavioural among others. The adoption of GIS has also been from an isolated point of view with each organization setting up GIS to meet its private needs. In spite of differences in the way GIS is being set up, there is a gradual progress in local authorities in both developed and developing countries in incorporating GIS usage in the urban planning activities. Campbell and Masser (1995) talks of the dynamic nature of planning and management work carried out at local authority level which has caused local authorities become major users of GIS. These organizations use large datasets which are geographical in nature to support their decision process. In the study of Worrall (1990) it was found that 80% of information handled by local authorities in both developed and developing countries are spatially related. However data accessibility poses problems to urban planners as most municipal database management systems in developing countries are manually operated.

Decentralization has also been playing a role in disseminating GIS in organizations. Ciancarella e*t al* (1993) noted a rise in GIS awareness in the Italian local government due to reforms and decentralization of power from Central to Local Government. In Malawi, the establishment of GIS within Blantyre City Council coincided with the Government's decentralization programme which gave the Council greater autonomy and responsibility to carry a GIS implementation programme.

It is also worth noting that GIS establishment in the local authorities worldwide has had varied applications. In Graafland (1996) research of GIS adoption in the Dutch municipalities he found out that 50% of GIS in the municipalities investigated had register functions only. None of the municipalities had GIS used at decision support level for strategic planning. GIS was more used for operational activities to register functions and surface calculations. Functional applications are still limited and in urban planning, the use of information systems is oriented more to development control than strategic planning as is the case with local authorities in Malawi. In none of the municipalities investigated was GIS used at decision support level to facilitate strategic planning. The existing GIS was for operational activities, including register and structured calculation functions. Goodchild, *et al*, (1990) cites that one of the main limiting factors to GIS progress in urban planning applications is that until recently, urban planning modeling programmes and statistical analysis functions used to stay separate from the spatial analysis components and communicated with each other via import-export functions.

In view of the foregoing, this paper will look at some examples on how low cost GIS are being used in Malawi to improve urban planning management and problems faced.

3.0 GIS APPLICATIONS

In recent years, there has been a wider adoption of GIS and remote sensing in urban planning in Malawi in the following planning activities:

a) Preparation of existing land-use maps, urban structure plans and other development plans
b) Study of urban sprawl over a given time period to understand the underlying driving forces
c) Assessment of land use conversion in different parts to help understanding of the impact of the policies pursued
d) Land suitability analysis based on physical, environmental and accessibility parameters to guide the selection process for opening the land for urban development
e) Accessibility analysis for proposed major development projects such as residential housing schemes, informal settlements upgrading projects etc
f) Evaluation of public suggestions and objections on the draft planning proposals
g) Publication of maps at various scales with relevant details.

Besides the above list, there are other urban planning activities that are gainfully carried out using GIS. The following are some of the planning functions where GIS has been applied to enhance the urban planning management:

3.1 URBAN STRUCTURE PLAN PRODUCTION

Urban Structure Plans for a given urban area is prepared for 10-15 year period. Its review is usually made after 5 or 10 years after the sanction. Obviously plan preparation or its revision is not a frequent exercise.

During the review of the Blantyre Urban Structure Plan, GIS and remote sensing were deployed to assist in the formulation of the Plan (*See Figure 2 below*).

Even after completion of the Structure Plan Project, the City Council is still utilizing GIS and remote sensing to fine-tune the Plan at its various implementation stages with regard to the constant urban scenario changes. Aerial photographs are being used to monitor terrain changes, vacant land pockets for new plot demarcations in residential areas; conversion of open spaces to other land uses and identification of revenue boundaries to determine property valuation lots.

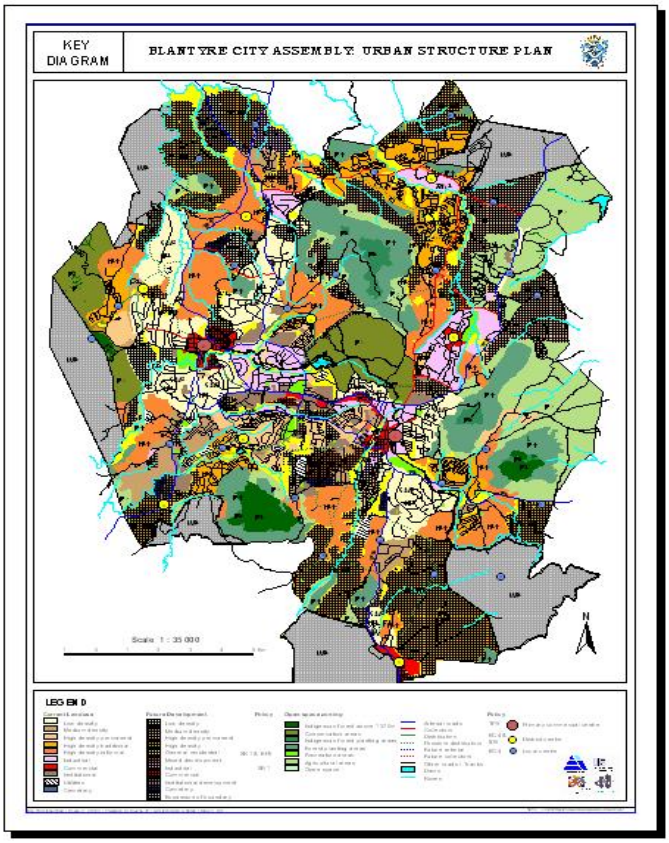

Figure 2. Blantyre City Urban Structure Plan

The Plan's database organized under GIS has also been providing useful spatial and non-spatial information to other allied urban planning and management activities.

3.2 INFRASTRUCTURE PLANNING - ROADS

Urban Structure Plans identify roads in different categories such as main roads, secondary roads and other roads that can be developed over the Plan period. Use of buffer generation tool to provide way-leaves for utility and road infrastructures. GIS utilities such as buffer generation, overlaying and clipping can come up with information that can assist contractors during road construction works.

3.3 DEVELOPMENT COMPLIANCE - STREAM RESERVE REGULATIONS

Ability to relate proposed development with distance from stream reserve or any reserve areas is another important aspect in development planning. Development control regulations require that any development close to a stream should leave a way-leave of 15m on both sides of the stream. A GIS system with this capacity can reduce time of frequent site visits to verify the situation on the ground. This information can also enable urban planners know in advance before processing development application on how much land on a plot is still available for the proposed development and decide on what course of advice or action should be taken on the application. In the Namiwawa layout above, a stream was buffered 15 metres on both sides using a GIS buffering tool to enable detection of illegal development encroaching into the stream reserve area. The same model can also be applied to high voltage power lines passing through a new residential area or house rolls along a road in need of health inspections or refuse bins.

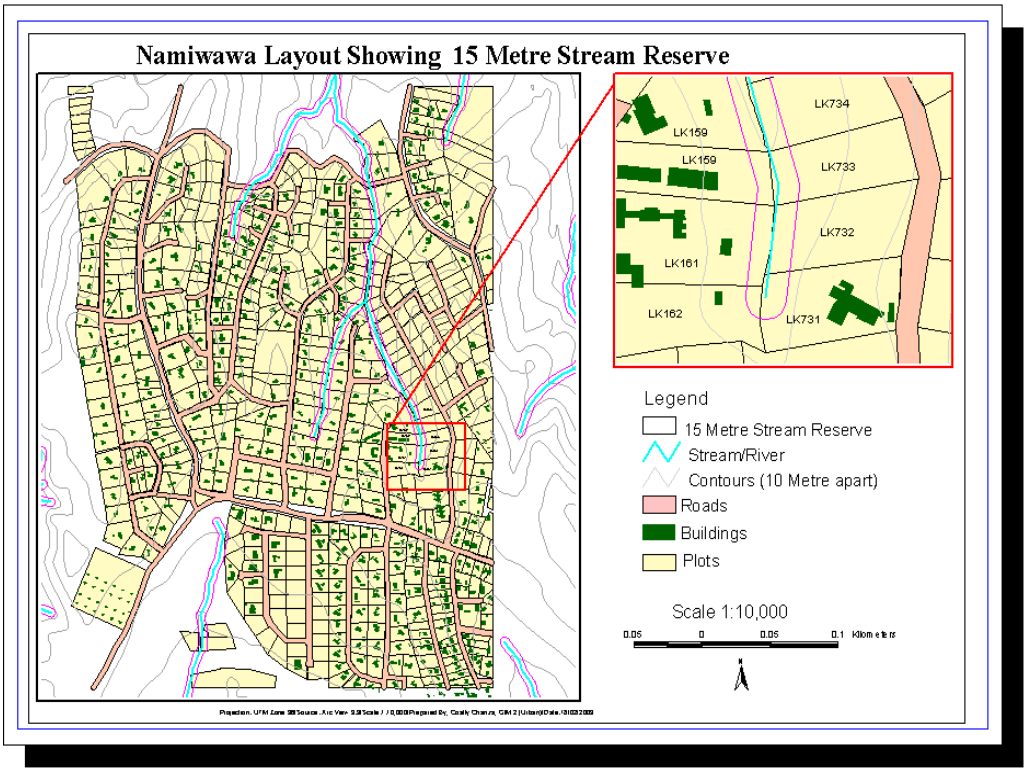

Figure 3: Development Compliance Map – Namiwawa, Blantyre

3.4 UTILITY NETWORKS

Planning for utilities like water supply, sewerage and storm water drain within the framework of a development plan is an equally important task. Augmentation of their capacities in relation to the projected population and economic activities in different urban pockets is a major responsibility of a Town or City Council. This gives rise to design challenges that can be adequately addressed by GIS functions. Some of these provisions are made by other specialized agencies like water boards and sewerage sections of Town or City Councils. Sharing of GIS database by various departments of the councils or with water boards can, therefore, prove economical.

In the Blantyre Urban Structure Plan, a recommendation was made on sharing of such information between the City Council and the utility organizations such as Blantyre Water Board (BWB), Escom (Power Company) and Malawi Telecommunications Limited (MTL). By displaying water utility layer with plot layer, planners are in a better position to know accessibility of a plot to a water pipeline source and also

whether there are any underground water pipes crossing the plot. This information can enable speedy town planning decision making on the application.

3.5 SITE SUITABILITY FOR URBAN DEVELOPMENT

Utilization of contour layer in GIS can enhance the ability of urban planners and municipal engineers to know the terrain situation of a particular plot or an area beforehand prior to a planning decision by the Town Planning Committee. Of primary importance is the need to establish the extent and distribution of actual slope terrain within the plan area. Such a slope inventory can provide sufficient information for appropriate decision to be made in advance. The information can also assist planners in assessing the development for any additional structural requirements, surface drainage details or sewer line connection specifications. As land slopping can entail high or low construction costs on the developers, local Councils have the mandate to ensure that development is sound and free from any instability threats from causal factors such as sloppy terrains. In infrastructure development, land below 15percent slope is normally considered less expensive to develop. Slope maps which have been clearly divided into slope gradations (0-8 % referring to easily developable land, 8-6 % for normal developable conditions, 16-24 % for quite difficult land and greater than 25 % for difficult land) can provide vital information. By specifying development land into these categories, planners are able to know which areas require special slope regulations for sound structural development. In the Namiwawa layout – slope variation map below, GIS spatial analyst was used to analyze the angular terrain component. By assessing the slope, a planner is able to respond to slope and development control problems as illustrated below:

Slope generation process using GIS

(a) Generation of Triangulated Irregular Network (TIN) theme from an existing contour layer theme.

(b) Slope derivation of the TIN theme from surface menu.

(c) Output slope (in degrees). GIS reclassification process in degrees transformed into %ages with the following formula:

$100 * \tan \alpha$ = slope (%), where α is slope (degrees)

Results

From Figure 4 below, it is noted that most slopes fall between 0 and 16 % which translate into normal development conditions. However a few plots like Plot LK 235 may pose difficulties to develop because part of the plot is steep land (falling between 16 and 32 %). Such a situation can enable the urban planners come up with general information and advise the applicant of the environmental implications and costs to be incurred when developing the plot.

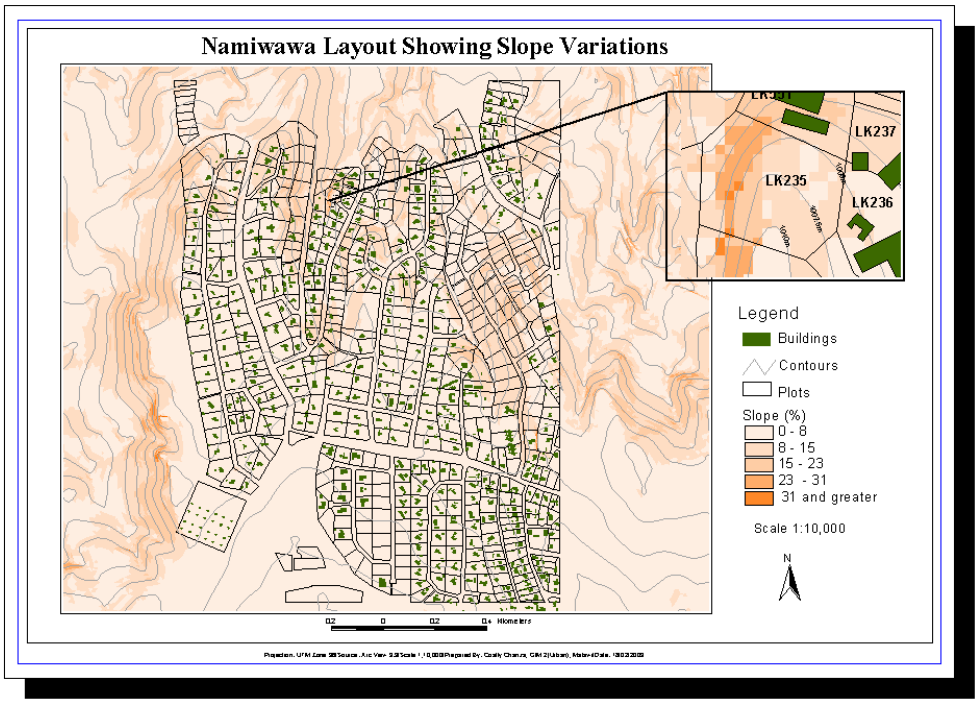

Figure 4: Site suitability map – Namiwawa, Blantyre

3.6. SOLID WASTE MANAGEMENT

Solid waste management in urban areas is emerging as a major issue. Identifying new dumping sites, evaluating the residual potential of the existing sites and formulating waste collection strategies are some of the critical components of this task which GIS can ably assist. The new proposed waste dumping site for Blantyre City in an area called Chigumula was identified using this method.

3.7. PLANNING DISASTER MITIGATION MEASURES

Natural disasters like floods in some town/district assemblies and man-made disasters like collapse of buildings due to faulty design and use of sub-standard material can paralyze the city life and economy. Contingency planning is necessary to meet such likely disasters. Appropriate spatial database showing the historic monuments, transport terminals, office complexes and other important places and transport network in their vicinity can help identify the escape routes and rushing the relief measures by using GIS network analysis utilities.

3.8. URBAN RENEWAL PLANNING

Presence of a large chunk of land under obsolete use is a common feature in districts, towns and cities. Closed down medium and large manufacturing units can be 'eye soles' to the urban areas. GIS can facilitate assessment of redevelopment plans for such areas keeping in view their citywide impact. In particular, planning the landscape and visualizing the effects of regeneration proposals can be simplified.

3.9. PLANNING OF URBAN SERVICES

Spread of computer and the use of internet are expected to increase in future in our urban areas. Posting of planning information on suitable website by the urban local bodies would, therefore, become essential. Access to modern and responsive service will be the demand of the urban residents in future. This can be initiated by posting of Development Plan, first at the draft stage and then after its sanction at a website to facilitate wider dissemination of information and public participation. On-line availability of planning proposal details at certain levels can be of great service for all those concerned.

3.10 INTERFACING WITH EXPERT SYSTEMS

Scrutiny of development proposals under development control regulations forms one more aspect of urban planning. Automation of this time consuming process is extremely desirable. This can be attempted by

constructing a suitable expert system[2]. Proposed Expert System has GIS database engine storing spatial and attribute data and inference engine drawing upon the development control regulations with suitable user-friendly front end tool to examine the proposal and produce remarks on the basis of logical interpretation of the rules and regulations. Blantyre City Council is currently utilizing such a system. MS Access has the capacity to display in a view approved or rejected developments once the SQL link has been established between tables. This is shown in *Figure 5* below using a database integration of MS Access with low cost GIS software.

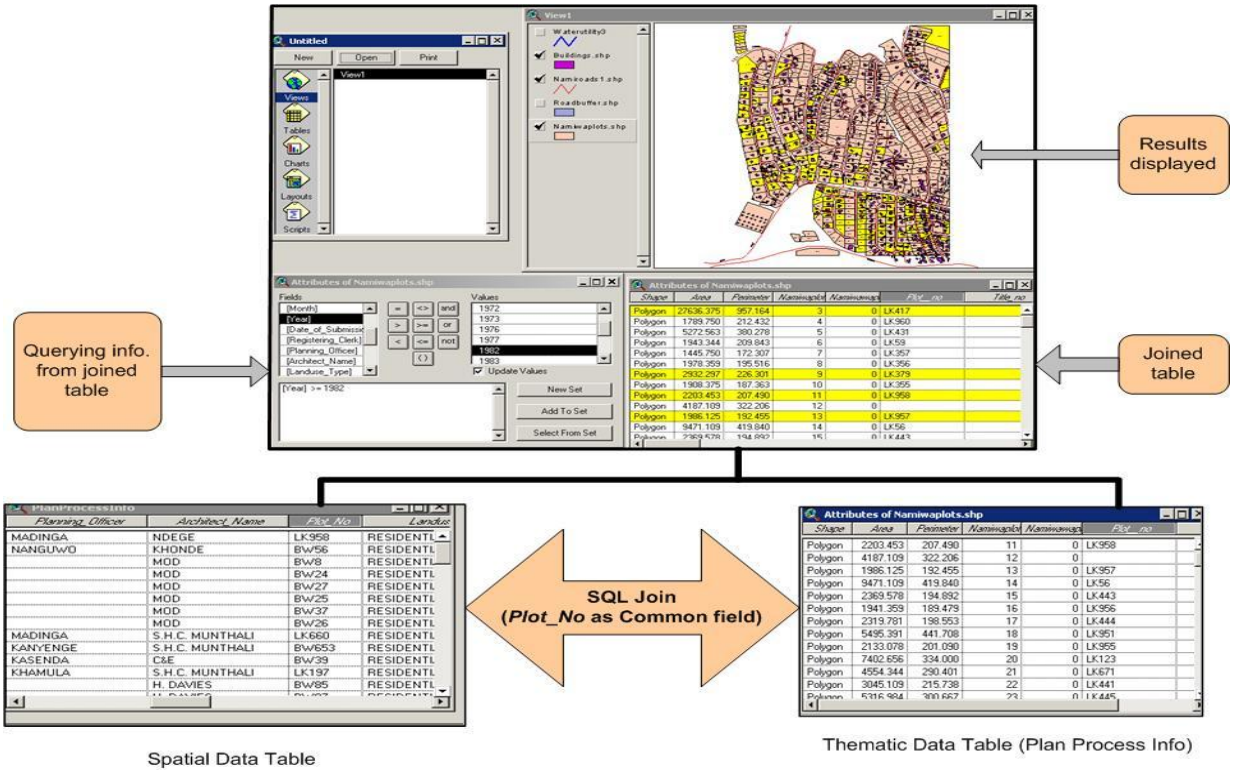

Figure 5: MS Access and GIS software database integration

Database design and also querying involves enormous tasks and complexities. Urban Planners or end users with little computer knowledge need a user friendly interface to achieve the goals of data management to facilitate quick and easy data entry, editing and retrieval. User interface in *Figure 6* was created using MS Access and linked to the MS Access database and the low cost GIS software.

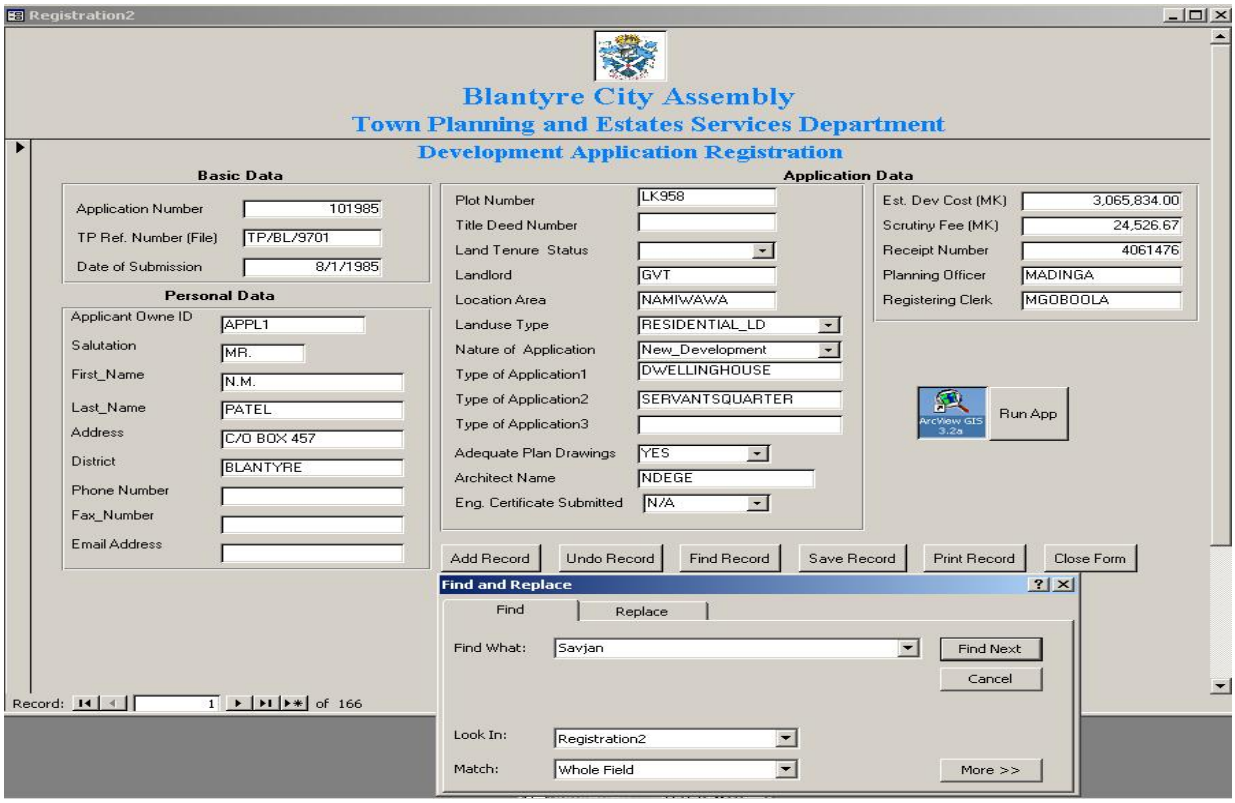

Figure 6: User interface created from MS Access

4.0 CONCLUSION

Urban planning and development is a continuous process and involves planners, administrators, developers, investors and the ordinary people living in the urban areas. Their perceptions, expectations and actions for complex analysis and rich envisioning capacity of GIS are found helpful to bring transparency in planning desired by the above groups. Use of low cost GIS and Remote Sensing technologies have capability to provide necessary physical input and intelligence for preparation of base maps, formulation of planning proposals and act as monitoring tool during implementation phases of the development plans. Large-scale urban development projects like urban structure plans take time to complete. Satellite imageries help to maintain truthful record of terrain during that period. Thus GIS and Remote Sensing can emerge as powerful technological tools in urban planning and management.

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APPENDIX 1

Figure 1b, digitized land at Ginnery Corner, Blantyre